HABITAT AND DISTRIBUTION OF THE FRESHWATER SHRIMP *PARATYA CURVIROSTRIS* (DECAPODA: ATYIDAE) IN NORTH CANTERBURY

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ABSTRACT

Changes in the distribution of the shrimp *Paratya curvirostris* in North Canterbury between 1940-1942 and 1975-1976 are described and discussed. The main reason for declining numbers of shrimps is the increased control of waterways over the years. The importance of the adventive fluviatile flora, as shrimp habitat is stressed. The biota of four streams in which *P. curvirostris* occurs is detailed. Large bullies were shown to be major predators on shrimp. The habitat of the larvae was shown to be estuarine, but could not be related to flora or salinity from the available data.

KEYWORDS: *Paratya curvirostris*, shrimp, freshwater, Canterbury, lowland stream Ashley Estuary, larvae, Atyidae, distribution, fauna, flora.

INTRODUCTION

As part of a study of the population biology of *Paratya curvirostris* (Heller, 1862) (Decapoda: Atyidae) in North Canterbury, a survey of the distribution of the species was undertaken. As well as providing information on current distribution the survey was able to provide data for comparison with that gathered by R.L. Nielson in 1940-1947 in the same area.

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METHODS

All the coastal streams in the North Canterbury area south of the Waipara River were visited in the summer of 1975-76. Intensive searches were made for shrimp with a 195 µm mesh net at each site. The 33 sites visited are shown in Figure 1.

At 4 sites where *Paratya curvirostris* was common, a detailed analysis of the fauna and its abundance was made by collecting samples and sorting them in the laboratory with the aid of a binocular microscope.

A search for zoeae in the Ashley Estuary (Grid ref. NZMS 1 S76 0887) was carried out on 16 and 29 February 1976 by walking up the lower water channel, and sweeping a 195 µm mesh net through all the different types of vegetation present and through the surface of the mud. At between 50 and 100 m intervals the net was emptied and the contents preserved. At the same time a surface water sample was taken for salinity testing. Larvae and other invertebrates were sorted from the samples under a dissecting microscope (x 20 magnification).

RESULTS AND DISCUSSION

SHRIMP DISTRIBUTION AND ABUNDANCE

Results of the stream surveys are shown in Table 1. Shrimps were found in 18 of the streams but were common in only 12.

In most cases, animals were more abundant where both well developed weed beds and floating fringe vegetation were present. In streams with weed beds but poorly developed fringes, shrimp abundance was low. On the other hand, where the fringe was well developed but weed beds were absent or sparse, shrimps were abundant though not as common as when both were well developed. Abundance was recorded on an arbitrary scale: 'very common' corresponding to the presence of shrimps in all likely habitats within 10 m of the initial sampling site; 'common' meaning shrimps were found in most places examined; and 'rare' indicating that few specimens were found despite careful searching within 0.5 km of the starting point.

The bed substrate of the streams examined did not appear to be related to shrimp distribution or to the presence or absence of weed beds or fringes. An exception to this general rule was the Wainui Stream on Banks Peninsula where the fringe was intermittent and poorly developed, but shrimps were common among willow roots (*Salix* sp.). This habitat did not occur in any of the other streams.

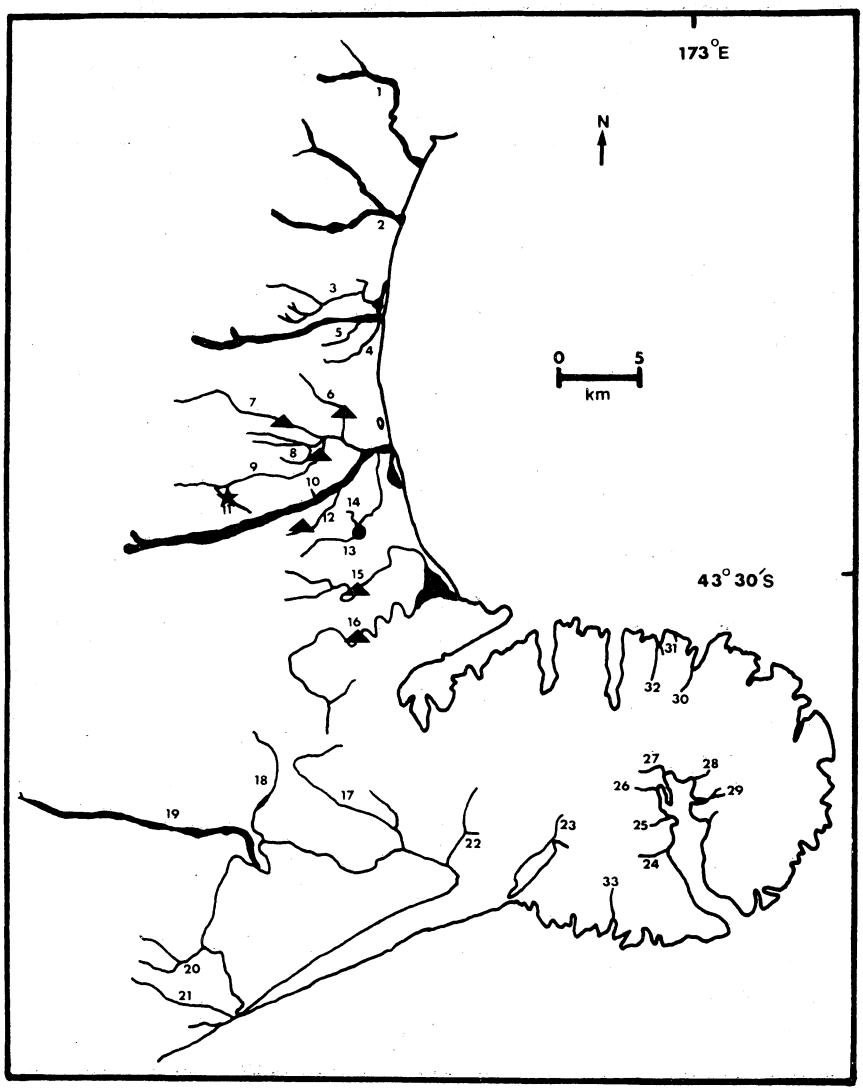

Figure 1: Locations of streams surveyed for *Paratya curvirostris* in North Canterbury. (See Table 1 for key to the streams).

Changes in distribution of *P. curvirostris* since 1940-1942 are indicated as follows:

★ No longer present

▲ Present but no longer as common

● No change

TABLE 1. RESULTS OF THE SURVEY OF NORTH CANTERBURY STREAMS FOR *PARATYA CURVIROSTRIS*.

Key to Fig. 1	Stream	Shrimp Abundance	Substrate	Weed Beds	Fringe
1	Waipara	-	stony	-	-
2	Kowhai	-	stony	-	-
3	Saltwater	***	mud	**	***
4	Taranaki	*	mud	*	**
5	Waikuku	***	stony	*	**
6	Cam	*	mud	**	**
7	Main Drain	**	stony	-	**
8	Ohoka	***	stony	*	**
9	Kaiapoi	*	stony	*	**
10	Goat	**	mud	**	**
11	Eyre	-	stony	-	*
12	South Branch	***	stony	**	***
13	Styx	***	mud	***	**
14	Kaputane	**	mud	**	*
15	Avon	**	mud	**	*
16	Heathcote	*	mud	*	**
17	Halswell	-	mud	*	**
18	L2	-	stony	-	**
19	Selwyn	-	stony	-	*
20	Hart's	*	stony	-	**
21	Taumutu	*	stony	-	*
22	Kaituna	-	mud	*	*
23	Little River	-	stony	**	***
24	Wainui	**	stony	*	*
25	French Farm	-	stony	-	-
26	Barry's Bay	-	stony	-	-
27	Duvauchelle	***	stony	***	***
28	Takamatua	***	stony	***	***
29	Robinson's Bay	-	stony	*	**
30	Little Akaloa	-	stony	*	**
31	Stony Bay	-	stony	*	**
32	Okain's Bay	-	stony	-	**
33	Peraki	-	stony	*	*

The primary factor determining the presence or absence of *Paratya curvirostris* in the coastal streams of Canterbury appears to be the gradient of the stream bed. Unless the slope is gentle it is impossible for vegetation to become established, and vegetation is required if shrimps are to occur.

Comparison of the findings in this study with those of R.L. Nielson (unpublished notes) is particularly interesting. Shrimps are now less abundant in areas common to both studies and have a more limited distribution than in 1940-1942 (Fig. 1).

There appears to have been a decline in the distance *Paratya curvirostris* penetrates upstream in the greater Christchurch and Kaiapoi areas (Fig. 1). During the period when Nielson was carrying out his field work, shrimps were common enough in many parts of the Avon River to support a fortnightly sampling programme, and the Heathcote River was apparently as heavily populated. In 1975-76, shrimps were only found in a few reaches of the Avon and then only in small numbers. Repeated attempts to find shrimps in the Heathcote produced only two individuals. More recently, however, Robb (1980) reported that *P. curvirostris* was common amongst submerged weeds, especially along the banks of the Avon, Heathcote and Styx Rivers, and particularly in their lower reaches.

Key to Table 1

Shrimp Abundance:

\- Absent
* Uncommon
** Common
*** Very common

Substrate:

stony - predominantly stones and gravels
mud - predominantly fine particles

Weed Beds:

* Some present
** Occupy one-quarter to three-quarters stream's width
*** Occupy most of stream's width

Fringe:

* Scattered, narrow
** Less intermittent, generally wide (20 cm+)
*** Continuous along bank, more than 20 cm wide

In the South Branch of the Waimakariri River, Nielson found that shrimps were quite common as far up as the Groynes. Now none are found at the Groynes, although they are still quite common in the lower reaches (there is now a weir below the Groynes and this may prevent shrimps living there). On the other hand, no evidence was found to suggest that there has been any decline in shrimp numbers in the adjacent Styx River. Within the Kaiapoi System, Nielson did not consider the Ohoka, but he found shrimps in the Kaiapoi River and the Main Drain. Since November 1975, large shrimp populations have become re-established in the Kaiapoi (Winterbourn and Stark 1978), although neither this study nor S.C. Toshach (pers. comm.) found any there in 1975-76. Their reappearance may be associated with the instigation of pollution abatement measures by the North Canterbury Wool and Fellmongery Ltd. which brought about marked improvements in water quality in the Kaiapoi River (Toshach 1976; Winterbourn and Stark 1978). Nielson noted the presence of extensive weed beds in the Main Drain during his field work; however, none were found in 1975. In addition, the fringe was poorly developed and shrimps were not abundant. The decline of the shrimp population in the Cam River since Nielson's time can probably be related directly to flood control measures which include frequent dredging and weed removal. The latter destroys both weed beds and the fringing vegetation.

As far as could be determined, *Paratya curvirostris* no longer occurs in the Eyre River, although Nielson found it there. His study did not extend north to Saltwater Creek, but several people who have lived in the region for many years have said that shrimps are not as common today as they were some years ago. If so, this also is probably related to management practices which have been instituted for flood control. These have involved a considerable lowering of the stream bed (about 50 to 100 cm) thus increasing the flow rate, which disturbs and limits the growth of weed beds and fringe.

Although it is difficult to associate cause and effect after so many years have elapsed, it is interesting to consider some possible reasons for the decline of *Paratya curvirostris* in Canterbury during the last 35 years. First, however, we must set more recent events against their historical background. What appears to have been a bitter controversy amongst people involved in freshwater fisheries management surfaced when Thomson (1922) stated that "shrimp *(Xiphocaris (= Paratya) curvirostris)* .....have been eaten out in streams stocked with trout." Thomson (1923) later added "wherever trout have been introduced and have thrived they have greatly reduced the abundance of these Crustacea and in many cases have nearly exterminated them" (referring to *P. curvirostris*). In the same work he stated "all that the society (North Canterbury Acclimatisation Society) is doing is to attempt to reintroduce this species into streams which have already been denuded by trout." Replying on behalf of the Acclimatisation Society, Godby (1924) said "I can show him several streams near Christchurch very heavily stocked with trout in which this particular shrimp is present in countless millions and forms the principal food supply of the trout." He went on to suggest that shrimp had never been found in the Selwyn or Opihi Rivers. Both of these are large rivers with periodic high flow rates and few or no macrophytes, and as such

are not suitable habitats for shrimps. It is possible that Thomson had elsewhere suggested that shrimps had been eaten out of these two rivers, although there is no reference to this.

Thomson (1879, 1903) had described and discussed the taxonomy of *Paratya curvirostris* and this indicates that, as a scientist, he was familiar with the animal. Similarly, as an officer of the Acclimatisation Society, Godby probably had a good understanding of events in streams in the vicinity of Christchurch. From consideration of the brief discussions by Thomson (1922, 1923) and Godby (1924) it is considered here that although introduced fish such as trout *(Salmo trutta)* have had some effect, probably on small populations of *P. curvirostris,* their impact has not been as great as suggested by Thomson (1923) and it is probable that shrimps have always had a discontinuous distribution.

It must be borne in mind that the major plant species utilised as habitat by *Paratya curvirostris* today *(Elodea canadensis, Agrostis stolonifera, Alopercurus pratensis* and *Nasturtium officinale)* are all adventives. *Elodea canadensis* has been present the longest, becoming established in the Avon River, Christchurch, in 1868 (Armstrong 1870).

The most obvious way that shrimp habitat can be modified (assuming the adventive flora can be regarded as a natural habitat) is by water course management for flood control, weed clearing, channel deepening and the like. The macrophyte communities in Canterbury lowland streams also have been affected by pollution, mostly from industrial sources, and as a result shrimps are affected. This can be seen best in the South Branch where the weed beds and fringe both virtually disappear below the outfall from the Belfast freezing works. Organic pollution also affects the amount of dissolved oxygen present in the water. Shrimps living in a weed bed with adequate but low oxygen levels during the day, as in a mildly polluted stream, are likely to suffer from oxygen deprivation at night when the plants begin to use oxygen instead of producing it.

As well as the factors outlined above, insidious factors such as DDT could have been involved in reducing populations of *Paratya curvirostris*. This type of pollution has been known to have serious effect on freshwater crayfish *(Astacidae)* in North America (Hobbs and Hall 1974), and between 1945 and 1973 DDT and other persistent pesticides were in everyday use in New Zealand. A sample of shrimps taken from the South Branch, Styx and Ohoka Rivers and Saltwater Creek in this study were analysed for DDT and its metabolites (pp-DDE etc) and Lindane (benzene hexachloride) by S.R.B. Solly of the Ministry of Agriculture and Fisheries. Lindane and pp-DDT were detected at levels of 0.012 and 0.092 mg kg^{-1} fresh, whole animal tissue, whereas pp-DDT and pp-DDT were not detected. Costa (1970), in the only study of the effects of pesticides on atyids, found that Lindane had no visible effect on *Caridina weberi*. However, he found that levels as low as 0.1 ppm of DDT in the medium markedly depressed the heart beat rate of that species.

SHRIMP HABITAT AND ASSOCIATED FAUNA

Shrimp habitat was studied in detail at four sites, two on Saltwater Creek (Stream 3 on Figure 1), and one each on the South Branch (Stream 2, Figure 1) and the Ohoka Stream (Stream 8, Figure 1). One of the Saltwater Creek sites was at the head of the Ashley Estuary and the other further upstream beyond the limit of tidal influence.

At the South Branch, Ohoka and upper Saltwater Creek sites the characteristic habitat of *Paratya curvirostris* was the floating vegetation forming the fringe along the banks. The characteristic plant species of the fringe were *Alopercurus pratensis, Agrostis stolonifera, Mimulus guttatus, Veronica americana* and *Nasturtium officinale* senso lato. As well, shrimp lived in beds of *Elodea canadensis* at the upper Saltwater Creek site. At the lower Saltwater Creek site the dominant macrophyte was the estuarine *Ruppia polycarpa*.

The fauna at each of the four sites is shown in Table 2. Three of the four stations had very similar faunal assemblages, whereas the fourth, Saltwater Creek 1, located in the Ashley Estuary, was rather different. The most abundant animals at all stations except lower Saltwater Creek were the crustaceans *Paratya curvirostris, Paracalliope fluviatilis* and *Cyprinotus flavescens,* the insects *Tanytarsus* sp., *Oxyethira albiceps, Deleatidium* sp. and *Microvelia* sp., a mollusc *Potamopyrgus antipodarum* and a species of *Hydra*. At Saltwater Creek 1, insects were less common and the estuarine isopod *Munna schuainslandi,* a mysid *Tenagomysis* sp. and *Potamopyrgus estuarinus* occurred commonly. Four fish species were seen in the streams.

The number of species recorded was comparable with the number described from some tropical flotant communities, although the dominant groups of animals present were different. In particular, libellulid dragonfly larvae are usually major faunal components of tropical flotant communities, whereas dragonfly larvae, of any sort, are rare in New Zealand streams. Fish are also more numerous in tropical streams and of the 45 common species found in mats of *Utricularia flexuosa* by Lim and Furtado (1975), 11 were fish. In the Canterbury streams, *Gobiomorphus cotidianus* and *Anguilla* spp. were the only fish living in the fringe. Oligochaetes and hydracarinid mites were rarely seen in the fringe of my study streams, although both are important groups living among *Eichhornia crassipes* in Malayan fish ponds (Michael 1968) and in mats of *Pistia stratiodes* in tropical Africa (Petr 1968).A major characteristic of the faunas of both the tropical flotant communities and the Canterbury fringes is the large proportion of microphagous species present. Petr (1968), in his study of *Utricularia flexuosa* mats, observed that two species of shrimp occurred when the mats were decaying. One of these, *Caridina thambipillai* is the only atyid recorded from a tropical flotant community. Apparently it is a detritivore and becomes a major faunal element when detrital production is high. Detritus formation in the fringe of Canterbury lowland streams appears to be fairly high all year round, and as *Paratya curvirostris* is a detritivore (Nash 1974, and author's observations), as are all known atyids (Cowles 1915; Fryer 1960), the fringe is a habitat that can support a high permanent population.

TABLE 2. Composition of the fringe fauna based on samples taken in March, April, May and October 1975, and January and February 1976.

One asterisk represents rare (an average of less than 10 individuals per sample), 2 asterisks represent common (11-500/sample) and 3 asterisks represent very common (over 500/sample). A sample was the animals caught in the net during the standard search for *Paratya curvirostris* S.W.C. = Saltwater Creek, P = present.

	South Branch	Ohoka	S.W.C.	S.W.C.1 (estuarine)
Crustacea				
Paratya curvirostris	**	**	**	**
Hemigrapsus crenulatus				*
Paracalliope fluviatilis	***	***	***	**
Munna schuainslandi				***
Cyprinotus flavescens	**	**	**	
Cladocera	**	**	**	***
Copepoda	**	*	**	***
Tenagomysis sp.				**
Insecta				
Collembola	*	*	*	*
Paradixa neozelandica	*		**	
Paradixa tonnoiri	*		**	
Austrosimulium longicorne	**	*	**	
Culex quinquefasciatus	*	*	*	
Tabanidae		*		
Macropelopiini	*	*		
Syncricotopus pleuriserialis	**	**	*	*
Tanytarsus sp.	**	**	**	**
Psilochorema bidens	*	*		
Pycnocentria evecta	**	**	**	
Pycnocentrodes aureola	**	**	**	
Oxyethira albiceps	**	**	**	**
Paroxyethira hendersoni	**	**	*	*
Triplectides obsoleta	**	*		
Hudsonema aliena	*	*	*	*
Hudsonema amabilis	*	*		
Polyplectropus sp.	*	*	*	

Table 2 continued...

	South Branch	Ohoka	S.W.C.	S.W.C.1
Helicopsyche		*		
Aoteapsyche colonica	*	*	*	
Oecetis unicolor		*	**	
Olinga feredayi	*	*	*	
Hydrobiosis umbripennis	*	*	*	
Deleatidium sp.	**	**	**	
Antiporus wakefieldi		*	*	
Liodessus plicatus	*	*	*	
Microvelia sp.	**	**	**	
Sigara arguta	**	*		
Elmidae	*	*	*	
Xanthocnemis zealandica	*	*	*	
Mollusca				
Physa sp.	**	**	**	
Potamopyrgus antipodarum	**	**	**	**
Potamopyrgus estuarinus				***
Pisidium casertanum	*	*	*	
Sphaerium novaezelandiae	*	*	*	
Ferrisia dorhnianus		*	*	
Other invertebrates				
Hydra sp.	**	**	**	
Cura pinguis	**	*	*	
Prorhynchus sp.	**			
Chordata				
Gobiomorphus cotidianus	P	P	P	
Anguilla spp.	P	P	P	
Rhombosolea sp.	P	P	P	P
Salmo trutta	P	P	P	
Galaxias sp.	P	P	P	P

The only predator commonly encountered in the fringe which was large enough to prey on *Paratya curvirostris* was the bully, *Gobiomorphus cotidianus*. Gut analyses of 19 bullies collected from the South Branch, Ohoka Stream and the South Branch in spring 1975, indicated that shrimps could be a numerically important dietary component (Table 3), particularly of larger fish. Thus, two 11 cm long bullies contained 12 and 15 shrimps, respectively.

TABLE 3. Gut contents of 19 *Gobiomorphus cotidianus* (body lengths 5-13 cm) taken from the Ohoka Stream, South Branch and Saltwater Creek in spring 1975.

Prey taxa	Presence of prey		
	Number of guts	Total prey observed	Range per fish
Paratya curvirostris	6	33	1-15
Ephemeroptera (larvae)	5	25	2-6
Mollusca	6	29	1-11
Trichoptera (larvae)	4	8	1-3
Chironomidae (larvae)	1	12	-
Unrecognisable materials	2	2	-

DISTRIBUTION OF SHRIMP LARVAE

The larvae of *Paratya curvirostris* were rarely found in regular samples of fauna so an intensive survey of the Ashley Estuary was undertaken to attempt to locate concentrations of zoeae. Locations of the sampling sites and the associated flora are shown in Figure 2 and results of the survey are shown in Table 4. The biota of the Ashley Estuary (Table 5) was little different from that of the Avon-Heathcote Estuary (Knox and Kilner 1973) except that *Paratya curvirostris* has not been found in the latter.

Shrimp larvae were found at salinities from 1-16%, although in a laboratory experiment, Carpenter (1977) found survival was largest at 18%, a salinity which may even be exceeded in the larval habitat when the tide is in. The lack of coincidence observed between larvae and plants suggests that larvae probably occur in or on the mud. Clearly, however, further research into their habitat requirements is required.

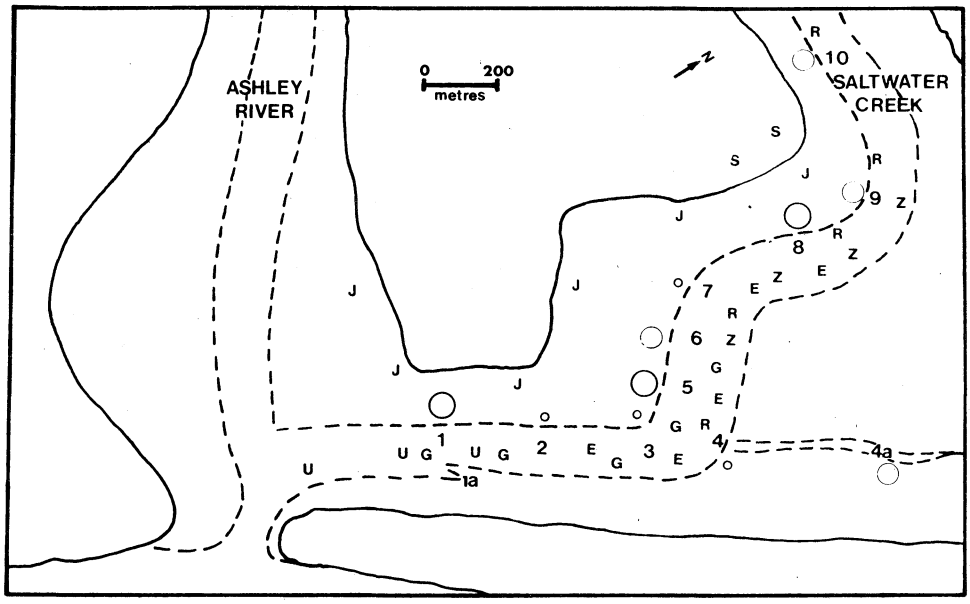

Figure 2. Distribution of shrimp larvae and vegetation in the Ashley Estuary, 16 and 29 February 1976.

Key:

O	*Paratya* larvae, < 10/sample	J	*Juncus*
◯	*Paratya* larvae, 10-30/sample	E	*Enteromorpha*
◯	*Paratya* larvae, > 30/sample	U	*Ulva*
	Low water river channel	G	*Gracillaria*
R	*Ruppia*	Z	*Zostera*
S	*Salicornia*	1-10	Station Numbers

TABLE 4. Summary of larval distribution in relation to salinity in the Ashley Estuary on 16 and 29 February 1976.

Rare = less than 10/sample, present = 10-30/sample, common = more than 30/sample

Stations	Salinity %	Larval abundance
1	5.3	common
1A	16.4	absent
2	4.4	rare
3	1.2	rare
4	1.9	rare
4A	9.0	present
5	5.3	common
6	1.6	present
7	1.6	rare
8	> 1	common
9	> 1	present
10	> 1	present

TABLE 5. Aquatic macro-biota of the Ashley Estuary. (determined on 16 and 29 February 1976).

Flora

Enteromorpha sp.
Ulva sp.
Zostera sp.
Gracillaria sp.
Ruppia polycarpa (?)

Fauna

Crustacea

Paratya curvirostris
Helice crassa
Halicarcinus whitei
Paracalliope fluviatilis
Gammaropsis sp.
Pseudosphaeroma campbellensis
Palaemon affinis
Hemigrapsus crenulatus
Macrophthalmus hirtipes
Paracorophium excavatum
Munna schuainslandi

Mollusca

Amphibola crenata
Sphaerium sp.
Macomona liliana
Potamopyrgus estuarinus
Paphies australe
Chione stutchburyi
Lepsiella sp.

Insecta

Chironomus sp.
Paroxyethira hendersoni

Fish

Aldrichetta forsteri
Anguilla sp.
Rhombosolea sp.
Cockabully (Taxon unknown)

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